

REMARKS

Claims 13-21, 31, 33-35, and 46-49 are pending in the application, claims 32, 36, and 39-42 being newly canceled herein. Claims 1-12, 22-30, 37, and 38 were canceled previously owing to a Restriction Requirement. Claims 43-45 were also previously canceled. Claims 13, 31, 46, and 47 are the only independent claims.

Claims Rejections - 35 U.S.C. § 103

Claims 13-21 and 31-36 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 5,871,446 to Wilk and U.S. Patent No. 6,135,960 to Holmberg and further in view of U.S. Patent No. 3,805,596 to Klahr or U.S. Patent No. 5,793,701 to Wright et al., either alone or further in view of U.S. Patent No. 6,503,204 to Sumanaweera.

Claims 39-42 and 46-49 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 5,871,446 to Wilk and U.S. Patent No. 6,135,960 to Holmberg and further in view of U.S. Patent No. 6,213,947 to Phillips et al.

Claim 13 Applicant has amended claim 13 herein to recite that electronic scanning of internal tissue structures is carried out via a plurality of data gathering apertures each including a plurality of transducers, that electronic 3D data acquisition includes generating a plurality of tissue-scanning beams via respective ones of the data-gathering apertures to capture or produce structural data pertaining to internal tissues and that the electronic 3D imaging includes coherently combining the structural data from the data-gathering apertures.

Applicant's invention as set forth in amended claim 13 is thus directed in part to the application of a second coherent aperture combining step (CAC) to already beamformed output signals of multiple data gathering apertures to improve the resulting image resolution. None of the references relied on by the Examiner discloses or suggests

coherently combining the structural data collected by tissue-scanning beams generated via respective data-gathering apertures each including a plurality of transducers.

The Wilk '446 patent teaches a flexible carrier web with a plurality of electromechanical transducers. The web conforms to the patient. There are apertures in the web for insertion of medical instruments. Telemedicine is a potential feature of the Wilk system. AI (artificial intelligence) techniques are disclosed for automated measurements of specific tissue characteristics for comparison against normalcy is taught. A switching circuit for firing transducers in sequence is used. There is no teaching on how one combines transducer signals to form 3D images. In particular, there is no teaching as to coherently combining data generated via the transducers.

Holmberg discloses an ultrasound scanning apparatus including a rigid lattice structure where each source and receiver (scalar elements) has a position that is known precisely and predetermined. Bistatic transmission is assumed (i.e., transmitting is carried out using sources different from the receivers). The lattice holds or is disposed in water and the patient is immersed into the system for full body imaging. Holmberg discloses the use of a full body coordinate system, with computer-controlled sonography (i.e., a computer controls the sensors and receivers to image a particular user-specified organ). Holmberg teaches the use of wavelet analyses taken from seismology. Holmberg further teaches a "common depth point imaging" method which appears to be an off-line focusing method. There is no real-time imaging (done off-line) but there is real-time data acquisition to support off-line processing. There is no teaching as to coherently combining data generated via the transducers.

Klahr introduces the ultrasonic phased array, patterned after phased arrays used in radar. At the time of Klahr's invention, the state-of-the-art in ultrasonic imaging was the use of a single, large diameter, ultrasonic transducer that produces a collimated beam (col. 11 lines 23-250) which typically would be moved mechanically to form a two-dimensional image. Alternatively, an array of such transducers could be used where the

mechanical movement would be replaced by electronic switching of individual elements. In either case, phase coherence was not maintained across the transducer positions so that the transmitted pulses could not be considered to comprise a single wavefront diffracted from a reflecting body (col. 10, line 65, to col. 11, line 4, and col. 6) and hence could not be used collectively in a beamforming operation. Klahr's invention of the ultrasonic phased array scanner (cols. 10-11 bridging) uses small-diameter sensing transducers and imparts phase coherence across the effective aperture, defined as the entire set of transducer positions as moved mechanically or as contained in an array but switched electronically. As a result, Klahr was evidently the first to perform across his effective aperture what today is known as beamforming, or more specifically (as pulses are transmitted and sensed successively across successive transducers), synthetic aperture beamforming. Klahr requires the positions of the transducer locations to be known and organized in a predetermined spatial pattern (col. 9, lines 13-42, and col. 21, lines 29-39). The only teaching that Klahr provides concerning the beamforming process itself, is that the transducer signal can be added coherently due to the maintained phase coherence (col. 7, line 59, to col. 8, line 14). Note that Klahr provides ample teaching of transducer position determination devices so that he knows the positions of a transducer element that is moved mechanically to define an "effective transducer array". He is determining element positions for a conventional beamforming process used with a single array.

Klahr does not teach applicants' use of coherent aperture combining to implement a level of additional resolution improvement *after* beamforming on individual data gathering apertures.

The prior art referred to in U.S. Patent No. 5,793,701 (Wright et al.) is mainly concerned with forming multiple receive beams on each transmit beam (or in general, forming more receive beams than the number of simultaneous transmit beams). The point is to get more receive beams in shorter frame time. The patent points out the

problems of degradation of image quality due to misalignment of Tx and Rx beams and due to interbeam interference if multiple Tx beams are used.

- there is a need to scan rapidly (high frame rate)
- prior art systems compromise image quality in favour of frame rate by undersampling the image - this leads to an artifact referred to as shift variance (sensitivity of the image field to small shifts of the sampling grid)
- prior art uses two or more independent receive beams simultaneously to detect echoes from one or more independent transmit beams (this allows one to maintain line density while scanning the desired region more rapidly).

Accordingly, the Wright invention improves upon the prior art by providing means to eliminate or substantially reduce the degradations (artifacts) by synthesising new coherent samples corresponding to synthetic scan lines that are spatially distinct from the receive scan lines (i.e. the receive beams). The Wright invention is *not* directed towards increasing image spatial resolution (associated with a finite transducer array aperture) but rather to reducing image artifacts while maintaining frame rate. The approach used is to collect and store complex samples (i.e. amplitude and phase; hence coherent) for one or more receive beams for each transmit beam (shot), where the transmit beams may be configured in sector scan, linear scan, vector scan, or other formats. Wright et al. then interpolate synthetic scan lines from these and use them to complete the scan lines for imaging.

Wright et al. provide no teaching on how to form and combine beamformed signals from a set of small subapertures in order to synthesize a larger aperture that provides significantly higher spatial image resolution than any of the beamformed signals associated with the small subapertures. Wright et al. do, however, refer to conventional synthetic aperture beamforming techniques to acquire a set of receive beams or scan lines to be used as input to their invention. To form a given synthetic aperture receive beam or scan line, they collect elemental echo signals in sequence from a set of non-overlapping

subapertures excited from acoustic energy transmitted along a particular scan line direction. These elemental signals are beamformed to produce a receive beam or scan line also steered in the same direction as was used during transmission. Wright et al. do not teach applicants' use of coherent aperture combining to implement a level of additional resolution improvement *after* beamforming (whether done using conventional sector, linear, vector or synthetic aperture scanning) which generates the scan lines associated with the individual data gathering apertures. Applicants' invention teaches how one coherently combines the scan lines from multiple data gathering apertures to improve spatial resolution over and above that afforded by an individual data gathering aperture.

Sumanaweera et al (US6503204) is not prior art to the present application. The Sumanaweera application was filed subsequent to applicants' filing date.

Claim 31 Claim 31 has been amended herein to incorporate the subject matter of claims 32 and 36, which have been canceled. To the extent that the Examiner's rejection of claims 32 and 36 apply to amended claim 31, applicants respectfully traverse the rejection of those claims and maintain that the subject matter of amended claim 31 distinguishes over the prior art and particularly over the reference relied on by the Examiner.

Accordingly, claim 31 now recites that the carrier includes a plurality of rigid substrates, that the coherently combining of structural data from the respective data-gathering apertures (part of applicants' 3D imaging process) includes determining relative positions and orientations of said substrates relative to one another, and that the determining of relative positions and orientations of the substrates includes executing computations according to a self-cohering algorithm.

These steps are not taught or suggested by the references of record.

Claim 39 In response to the Examiner's rejection of claim 39 as unpatentable over Wilk and Holmberg in view of Phillips et al., that claim and the claims dependent therefrom have been canceled.

Claim 46 Claim 46 has been amended herein to more precisely cover a feature of applicant's invention whereby 3-dimensional internal structural data is obtained by using essentially one-dimensional transducer arrays. Pursuant to amended claim 46, the electromechanical transducers are arranged in a plurality of arrays each taken from the group consisting of 1D and 1.5D arrays. Supplying and receiving steps are executed to effectuate an electronic scanning of internal tissue structures in accordance with the length dimension of each 1D or 1.5D transducer array and an electronic scanning of the internal tissue structures in accordance with the width dimension of the arrays, where the length dimension of a given array is typically larger than the width dimension. Conventional electronic scanning using 1D or 1.5D arrays is carried out in accordance with the length dimension and is usually referred to as scanning in azimuth or horizontal scanning. Elevation or vertical electronic scanning is not afforded by conventional 1D or 1.5D arrays. Applicants' invention provides both scanning in azimuth as well as elevation.

Nothing in the art of record enables such a scanning in elevational and azimuth relative to each linear transducer array.

Claim 47 Claim 47 has been amended herein to recite that sensors are disposed in data-gathering arrays or apertures on respective rigid substrates mounted to a flexible carrier, that the sensors are activated to generate a plurality of tissue-scanning beams via respective ones of data-gathering arrays or apertures to capture or produce structural data pertaining to said internal organic structures, and that the structural data from the data-gathering arrays or apertures is combined.

None of the references of record discloses or suggests the disposition of sensors in data-gathering arrays or apertures on respective rigid substrates mounted to a flexible

carrier or the combining of structural data generated from the different data-gathering arrays or apertures. None of the cited prior art patents teaches the concept of multiple, rigid, data gathering apertures in a flexible web, each of which performs beamforming in the conventional sense, but whose beamformed signals are then combined coherently or noncoherently (i.e. across data gathering apertures) to improve imaging. The prior art **deals with scalar transducer elements or use of single arrays** (i.e., scalar elements in a rigid, organized structure). Applicants teach a beamforming method that operates *across* these structures.

Conclusion

For the foregoing reasons, independent claims 13, 31, 46, and 47, as well as the claims dependent therefrom, are deemed to be in condition for allowance. An early Notice to that effect is earnestly solicited.

Should the Examiner believe that direct contact with applicant's attorney would advance the prosecution of this application, the Examiner is invited to telephone the undersigned at the number below.

Respectfully submitted,

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Dated: May 8, 2006